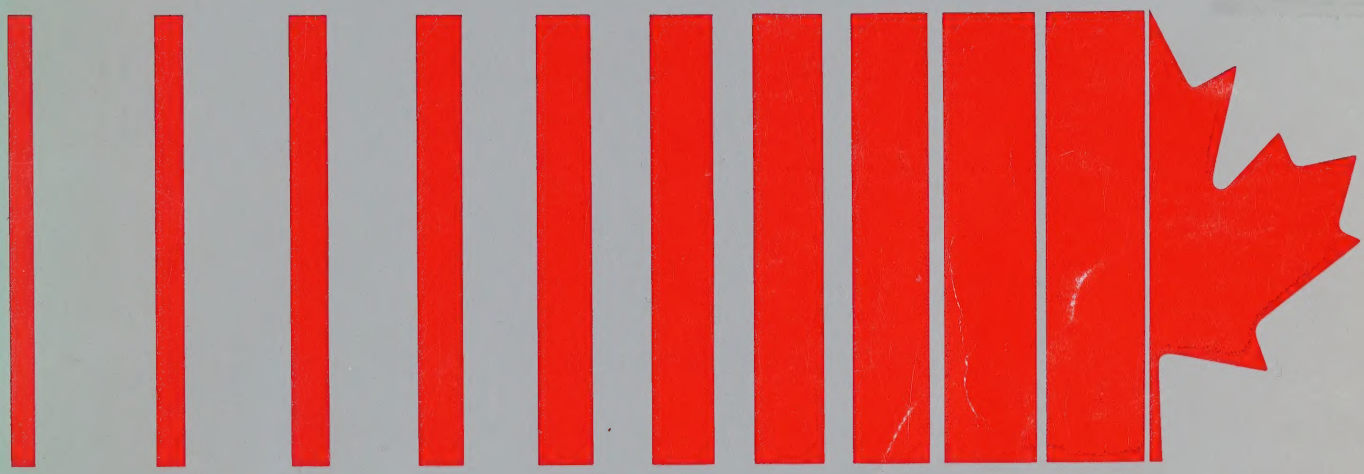
Task Force on Federal Policies and Programs for Technology Development



A Report to the
Honourable Edward C. Lumley
Minister of State
Science and Technology

Canada

July 1984

Ministry of State
Science and Technology
Canada

Ministère d'État
Sciences et Technologie
Canada

REPORT

OF THE TASK FORCE ON

FEDERAL POLICIES AND PROGRAMS

FOR TECHNOLOGY DEVELOPMENT

Canada

Cat. No. FT31-17/1984E
ISBN 0-662-13390-0

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PREFACE

In November, 1983, the Minister of State, Science and Technology, Economic and Regional Development, the Honourable Donald J. Johnston, asked us to examine the effectiveness of the federal government's efforts to promote technological development in Canada. We were asked, in particular, to explore four areas of concern:

* How effective are the government's industry-support programs, and how can they be improved?

* How can Ottawa use its purchasing power to advance the cause of private-sector research and development?

* How relevant and responsive are the universities to the R&D needs of the private sector? How aware, in turn, is industry of the opportunities and benefits available from the immense knowledge base that the universities represent? And how can this industry-academic relationship be improved?

* Who uses the federal laboratories? How relevant is their work to industry's needs, and to the government's economic and social objectives? How effective are their partnerships with the industries they were designed to serve? What sort of research should these labs be doing? What kind SHOULDN'T they be doing? How much input should industry have in choosing the labs' projects and setting their priorities? How effective are the mechanisms now in place for technology transfer?

In view of the urgency of the subject, involving the livelihood of millions of Canadians, we were asked to report within six months. This has proved to be a realistic goal. Although our research was extensive, and although we heard from a broad cross-section of industrial, scientific and professional bodies, we found a remarkable degree of unanimity concerning the future directions in which federal technology policy should move.

We are encouraged by this broad consensus. It means there should be relatively few institutional or political barriers to the implementation of a more effective approach to technological development. Nor are there financial barrier. We are persuaded

that, although allocation strategies could be improved, the federal government need not spend vast additional sums on technology development.

This report, accordingly, is fairly brief. But its findings are based on a large volume of research, including:

* A review of the available literature on the management of technological development. This literature turned out to be surprisingly extensive, since most industrialized nations are facing the same problems and opportunities that Canada now faces.

* In response to invitations from the Task Force, some 300 associations, corporations and individuals submitted written briefs.

* Members of the Task Force, or of its secretariat, conducted about 100 formal and informal interviews with representatives of large and small businesses, of provincial government agencies, of universities and financial institutions, and with senior officials and scientists in various departments of the federal government.

* Several Task Force members, often as a by-product of their own business travel, also interviewed relevant authorities in the U.S., Britain, France, Germany, the Netherlands, Denmark and the Scandinavian countries. A bibliography and list of all submissions, visits and meetings are included in the appendix.

The following report is based on a review and extensive discussion of all these sources by Task Force members, plus their own background and experience in various aspects of technological development. In submitting it, we wish to acknowledge the contribution of the Task Force's Secretariat, whose members were representative of nine federal departments. Our work would not have been possible without the dedication and expertise of: John Aitken, Alain Barbarie, Jack Elliott, Pat Gibson, Wolf Illing, Rick Lawford, Lorne Leonard, Rachel Potvin, Alexander Ross, Howard Sprigings, and Andrew Wilson.

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INTRODUCTION

At the risk of belabouring the obvious, we begin with a few assumptions and definitions.

Technology, according to our own working definition, means tools and the capacity to create and use them. Technology is thus not just about machines; it's about the skills and knowledge and ability of people to develop and use tools which make their lives more enjoyable and productive. Technology, in other words, is "know-how and know-why". As such, it's a social, cultural and educational phenomenon which cannot be considered in isolation from its human context.

The issues of technology development and educational policy are thus intertwined. You can't have one without the other. Technology policy involves a commitment to our most fundamental natural resource: the brains and skills of Canadians. It's not only a question of ensuring that our universities, colleges and institutes of technology are producing people with the requisite scientific and technological skills. It's also a question of ensuring that those trained people are allowed fully to develop their potential, and that all components of Canada's scientific establishment--government, industry and educational--are usefully involved in the process. Training scientists and engineers is important; but having jobs for them to go to after graduation is at least equally important. Government policies and programs thus have a key role to play in facilitating the full development of our intellectual resources.

In a six-month timeframe, it was not possible for this Task Force to address fully one of the most crucial issues of all: the social impact of new technologies. They have great potential to improve the quality of all our lives. To realize this potential will require that we marshal our wit and skill, bringing together labour and management in productive enterprise. We discussed and debated the subject in great detail, and concluded that the subject is too important and too complex to be treated merely as a side-issue of our enquiry. A task force or organization devoted to that subject alone, we believe, would be a more appropriate response to the urgency and magnitude of the issues involved.

New technologies are created through a series of steps that begins with a pure, almost playful, process of exploration, and ends with the development, engineering, manufacturing and marketing of useful products. Most frequently, the ultimate test of these products' usefulness is the extent to which people are willing to pay for them.

This last point needs emphasizing. All technology development should be aimed at producing something useful. The best test of utility, we believe, is the market itself--that is, the perceptions and responses of the industries and consumers on whose behalf, presumably, the research is being conducted. Pure research may not have immediate applications, but it operates in one of the most ruthless and unforgiving of all markets: other researchers next door and around the world. Their assessments of each other's work, and the extent to which their achievements provide the basis for further work, adds up to a research environment that, in our view, is healthily competitive.

The most effective research and development, we believe, is "demand-driven", where the research is undertaken in response to a clearly-defined need. The Apollo program, which put a man on the moon by a pre-set deadline, was such a program. All Apollo research, from the purest to the most applied, was directed towards the attainment of a single, urgent goal. The work of the Alberta Oil Sands Technology Research Authority (AOSTRA) has been similarly effective, because the goals of its research effort have, from the start, been clearly defined: to discover and develop cost-effective, environmentally acceptable means of exploiting the Alberta tar sands.

The least effective technology development is "supply-driven", where the research institutions, rather than an external market, define the problem and, at their own speed, seek solutions. Sometimes they come up with brilliant solutions for which there is no problem --and products for which there is no market.

We think it's helpful to picture this innovation process as a chain which stretches from pure research to the introduction of new products. Like a real chain, it responds better if it's "pulled" by market demand than if it's "pushed" by research and technology development. The main thrust of our findings is that the federal government's involvement in technology development must be redefined to maximize the market's "pull" on the innovation process.

We believe this task is more urgent now than ever before. In an environment of increasing global competitiveness, our ability to develop and apply new technologies has become crucial to our continued prosperity. Our resource-based exporting industries will be subjected to increasing price competition from foreign suppliers. Canadian manufacturers, especially those relying primarily on the domestic market, face equally severe international competition.

This unforgiving economic climate is creating new demands on our capacity to innovate. Canadian industry is just beginning to respond to this challenge, and still has a long way to go.

The extent of a nation's commitment to technology development is commonly measured by the ratio between gross expenditures on research and development (GERD) and gross domestic product (GDP). By this yardstick, Canada ranks low on the scale of industrialized countries--far behind the U.S., Japan, Germany and Sweden. In recent years, our R&D expenditures have fluctuated between .95 percent and 1.24 percent of GNP. The range in the countries mentioned above, is between two and three percent.

This is not necessarily grounds for concern. The effectiveness with which our R&D funds are deployed, in the context of our particular circumstances, is more important than how much we spend. If we doubled R&D spending tomorrow, the economic impact of that increase would be quite marginal. Spending more on R&D makes no sense unless it's spent in a culture that feels compelled to compete. Such competitive environments create a need for innovation, which generates demands for still more research. This self-reinforcing pattern is the hallmark of all vigorously growing economies.

In our experience, successful industrial research depends on close liaison between the people in the labs and the people on the firing line--those responsible for manufacturing and selling. Typically, at least 90 percent of industrial R&D budgets is devoted to the explicit demands of marketers and manufacturers; only 10 percent or less is devoted to "curiosity-driven" research.

This shouldn't be surprising. In the real world, there is surprisingly little "pure" innovation. Most scientific advances consist of marginal accretions to

the existing lode of knowledge. And the vast majority of industrial innovations are not so much "new" as they are new adaptations or novel applications of proven technologies.

This point should also be stressed because, in the course of our enquiries, we detected in some quarters a certain wistful impulse towards an "all-Canadian" R&D effort. In our view, there is no such thing as technological sovereignty. Scientific knowledge can be drawn--and should be drawn--from many sources. No country, particularly one with a population as small as Canada's, can hope to be self-sufficient in science and technology. And from the standpoint of international competitiveness, it is far more desirable to ADAPT technology to local conditions and needs than to create it anew. It is important to remember that Northern Telecom did not invent the digital switch; IBM did not invent the digital computer and the Japanese did not invent the factory robot.

While developments in the more glamorous, strikingly original fields such as bio-engineering or fifth generation microtechnology will be important to the country's future, we suspect that most of tomorrow's technological success stories will involve the use of Canadian skills to develop creative new adaptations and extensions of existing and imported technologies. If we're lucky, most of our triumphs will consist of brilliant adaptations, using new technologies to revitalize old industries, such as forestry, mining, fishing, manufacturing or even textiles. New industries will be created through the application of high technology, but the biggest impact of this technology in Canada will be from the redemption of existing industries.

For a variety of historical and political reasons, the federal government is now involved at nearly every stage in the innovation chain. Through the federal laboratories, through funding of university research, through various incentive programs aimed at encouraging technology development by private industry and through its procurement, Ottawa is a major player in technology development--including even the final stages of manufacturing and marketing.

Although federal support of R&D will continue to be essential to Canada's status as a developed country, we have serious reservations about the nature and extent of

Ottawa's current involvement in the innovation process. Government participation and support is far more effective at some stages of the innovation chain than it is at others. At some stages it can be--and frequently has proved to be--ineffective.

It is an axiom of industrial research that not every great idea makes a great product. But when government is the player, it is very difficult to abort an unpromising research project let alone one which seems to show promise once it's got started. In industrial research, admitting failure or abandoning concepts that work technically but won't sell is a routine and accepted part of the process. In government, however, acknowledgement of failure is often postponed as long as possible. And when government finally does bite the bullet--the Avro Arrow cancellation comes to mind--the political consequences are often unwelcome, and a precedent is set for further risk-avoidance in the future. Public servants and their political masters are, by nature, risk-averse; research and development, by its very nature, is an exercise in the management of risk. It is not a promising combination.

The most strikingly successful examples of government involvement in research and development and the innovation process are to be found in wartime, and in the nineteenth and early twentieth centuries, in the work of Agriculture Canada and the Geological Survey at a time when industrial and university-based research scarcely existed in Canada. In our view, much of this early success can be attributed to the existence of clearly-defined research mandates, and to the fact that various government departments, in their role as "consumers" of the researchers' output, played a central, demand-oriented role in choosing research projects and setting priorities.

We believe that the responsibility for actively supporting technology development should be made an explicit part of all appropriate departments' mandates and that the Chief Science Advisor should report regularly to the Prime Minister on technology development issues.

One of our report's major findings can be summed up this way: Everybody needs customers. The innovation process, in other words, functions best when it's subjected to real-world demands, when research and development are conducted FOR somebody.

INDUSTRY SUPPORT PROGRAMS

The federal government's "alphabet soup" of technology support programs has become a pervasive factor in the Canadian industrial environment. Very little private sector research and development is now undertaken without some form of federal incentive. This may be less a tribute to the effectiveness of these programs than it is a demonstration of the private sector's ability to maximize its opportunities. The various programs are administered by several departments and agencies, are operated according to varying administrative criteria, and were initiated for a variety of reasons, some of which are no longer apparent. Taken together, they constitute subsidies amounting to at least $500 million annually.

The most important programs include:

* Industrial and Regional Development Program (IRDP): A new program, administered by the Department of Regional Industrial Expansion, which replaces seven programs formerly administered by the Department of Industry, Trade and Commerce and the Department of Regional Economic Expansion. IRDP is a veritable pinata of discretionary subsidies aimed at stimulating economic activity, creating jobs in slow-growth regions and promoting technology development. Total funding in 1983-84: $102.7 million.

* Included in this total is the $8 million annual budget of the DRIE-administered Industrial Energy Research and Development Program (IERD), which funds private-sector research aimed at reducing energy consumption.

* Defence Industry Productivity Program (DIPP): Assists firms exporting military hardware with grants for product development, acquisition of machine tools and testing equipment and some aspects of marketing. Total budget in 1983-84: about $169.2 million.

* Industrial Research Assistance Program (IRAP): A six-pronged program, administered by the National Research Council, to promote applied research in the private sector. NRC personnel in 21 centres across the country dispense advice and information on industrial engineering techniques, help smaller firms solve specific technical problems, make grants for specific

laboratory investigations or technical projects, as well as larger grants for longer-term industrial research projects. Total 1983-84 budget for all six sub-programs under IRAP: $48 million.

* Program for Industry/Laboratory Projects (PILP): Another NRC-administered program, designed to assist private firms in exploiting the commercial potential of research conducted in NRC, other government and university laboratories. 1983-84 budget: $23.9 million.

* The Department of Supply and Services (DSS) also sponsors several policies and programs which have an impact on technology development. These are discussed in the section of this report dealing with government procurement.

* In addition, there are other agencies with programs dealing with specific problems, or with specific industrial sectors whose mandates encompass some involvement with technology development. These include the New Crop Development Fund; Design Canada; a multi-million dollar program to assist Canada's troubled textile and clothing industries; the Critical Skills Training Program (CTST); and so on.

It is not possible, in a study of this scope, to provide detailed evaluations of the effectiveness of each federal program. But the following generalizations apply to most of them:

* Most of these programs are attempts to "push" on the innovation chain. Their fundamental strategy is to subsidize the costs of industrial research and development, on the theory that industry will be encouraged to undertake R&D if someone else is sharing the costs and the risks.

* Most programs are over-administered, and their responsibilities frequently overlap. It often requires prodigious consultation and paperwork on the part of the programs' applicants--so much so that, as confirmed in our interviews, many companies have concluded that it isn't worth their trouble to apply. The smaller the company, the less able it is to afford this paper burden.

* The complexity of the procedures for evaluating applications, and in monitoring the resultant expendi-

tures, are based on a laudable desire to avoid squandering public funds on dubious projects. But this commendable caution is antithetical to the spirit of successful industrial research. By its very nature, R&D is a leap into the unknown, often involving the commitment of expenditures with no guarantee of a return. Risk and failure are an inevitable--even desirable--part of the process. In its attempts to ensure in advance that the public's money will be well-spent, the bureaucracies that administer these programs have created a system which, in the view of the people it was designed to serve, is excessively risk-averse and cumbersome. Programs whose very purpose is to share risks are administered by the risk-averse. Thus, the administration of technology development programs should be simplified to reflect a much greater willingness on the part of government to share the risks of technology development.

* Very few of these programs have anything to offer start-up companies. Most incentive programs are designed for firms with established track records.

* The programs most highly praised in briefs and interviews were IRAP and, to a lesser extent, PILP. We found a strong consensus among industry spokesmen that they really do work--and we think we understand why. Both programs are administered by the National Research Council, an organization which, as one might expect, fully understands the risky nature of the projects it supports. Because the administrators of IRAP and PILP speak the same technical language as their corporate clients, these programs are managed in a far less complex, far more business-like manner.

* There is a corollary here. The program which is perceived as the least useful in promoting technology development is IRDP, administered by DRIE. (We appreciate that IRDP is a new program which may have growing pains. But its operating philosophy is perceived to be the same as that of its predecessor, the Enterprise Development Program (EDP), which was widely criticized for its elephantine management style.)

Encouraging economic development in slow-growth regions is one thing. Encouraging the development of technology is quite another. The goals of regional development and technology development are parallel, but not always complementary. Trying to serve both goals within a single program, namely IRDP, has created a frustrating situation in which neither goal is adequately served.

One possible alternative to the funding of small industrial R&D projects, of say less than $35,000, would be for the federal government to delegate this responsibility to provincial organizations.

This report does not attempt to provide quick-fix answers to complex problems. It is intended to be a roadmap to future policy directions, not the vehicle that takes us there. Nevertheless, we believe that responsibility for administering the technology-development portions of the IRDP should be transferred from DRIE to the National Research Council.

Further, we recommend a thorough review of all these programs be carried out by a responsible ministry or department, with a view to gradually phasing out those which have failed to win the endorsement of their intended clientele. In general, we would prefer to see a system based on government procurement and tax incentives and other climate-setting mechanisms, rather than on administered subsidies.

We stress the word "gradually", because the "alphabet soup" programs have become a deeply-entrenched feature of the Canadian industrial scene. Jettisoning them suddenly would create more problems than it would solve.

But we are strongly convinced that this is the direction to follow. Attempting to promote industrial research by subsidizing the private sector is an approach with serious strategic weaknesses, mainly, the enticement of industry into bureaucratic traps. It sometimes encourages firms to undertake dubious R&D projects which would be uneconomic without government assistance. It sometimes encourages firms to collect federal money for research they might well have undertaken anyway. It encourages the growth of bureaucracies whose risk-avoiding propensities militate against successful R&D.

The overriding test of all technology-related programs in support of industry should be: do their intended clients endorse them? If not, why are they there?

Over the years, Canada has put in place an extensive system of tax measures to encourage industrial R&D. It is our assessment that this is a generous system, and that the most recent changes will greatly

stimulate research by industry. In our conversation with industry, there was a generally expressed preference for support through the tax system over specific grants. Maintaining the tax system in its present form will, in our view, to a growing extent replace the need for many of the specific industry programs.

Our only comment on the system relates to the definition of research and development. We detected unanimous support for the need to extend the R&D definition that is now used by Revenue Canada, to make it more compatible with the definition used in the United States. If this were done, certain work that Canadian companies now do in the U.S. might be done instead in Canada. This change would also, incidentally, show a higher GERD than the present definitions produce.

GOVERNMENT PROCUREMENT

It is no coincidence that some of this century's most awesome scientific achievements have been made in times of war. Military requirements create an immense demand for scientific innovation, and a state of war makes it urgent that these demands be fulfilled.

We do not advocate the creation of a Canadian military-industrial complex as a means of stimulating technology development. But we do advocate its peacetime equivalent: a policy that would effectively utilize the federal government's immense purchasing power to promote private sector innovation.

Government high technology procurements afford the market pull mechanism required for more effective scientific innovation. The demand for leading edge technology forces innovation without all the constraints of commercial markets. Subsequent to these leading edge technology applications, a second market pull brings the technology eventually to commercial application with further developments being applied. In other terms, the government through leading edge technology procurement becomes an innovative user, which considerably increases the probability of success for the innovative supplier. Procurement-based programs also afford competition, which ensures the participants develop competitive strengths and, as well, have long-range continuity.

A procurement-based innovation policy must recognize that Canada participates in world markets; and access to larger high technology procurements than Canada can provide solely on its own must be assured. The Canadian government can give this assurance through international production-sharing agreements, and through participation in multi-country joint venture projects. In addition, its own procurements should encourage innovation to the maximum extent practical.

There are a few Canadian firms, with commanding positions in world markets, whose products were first developed under government contracts. In effect, government procurement exercised a venture capital function, sharing the early risks in the hopes of gaining access to a state-of-the-art product or process. Seakem, for instance, an ocean engineering firm based in Sidney, B.C., got its start in 1974 from a federal contract. The firm now employs more than 50

scientists and technicians across the country. Similarly, SED Systems Inc. received a number of government R&D contracts during its start-up and it now employs more than 300 people.

For the government departments involved, backing these firms with purchase orders was a risky thing to do. The technology-development programs they sponsored might not have resulted in useful products. The public servants responsible for procurement might have been accused of "wasting" government funds. But the result was the establishment of a significant Canadian presence in several high technology areas, and the creation of hundreds of new jobs in the private sector.

The distressing thing about these examples is their rarity. We cite them as examples of the beneficial effects that can flow from the use of government procurement as a tool for the promotion of innovative research. But in the Canadian context, these examples are the exception, rather than the rule. They came about almost in defiance of existing policy, rather than as a result of it.

And yet, the U.S. experience offers grounds for supposing that technology development can effectively be encouraged through government procurement policies. In the course of our research, we were especially impressed by the activities of the U.S. Defense Department. The Defense Advanced Research Procurement Agency (DARPA), alone spends about $880 million annually on state-of-the-art R&D and technology development. DARPA's sponsorship of hundreds of risky, state-of-the-art projects--many of which never result in useable products --has resulted in the creation of literally thousands of innovative companies, and tens of thousands of new jobs.

In Canada, there are proportionately far fewer successes. Many government departments pay lip service to the importance of technology development, and are happy to support it through their procurement policies --so long as they're not held accountable for the inevitable failures. No Minister or senior public servant with procurement responsibilities welcomes the prospect of defending their risk-taking propensities before the Auditor-General or the House of Commons' Public Accounts Committee. What is lacking, we believe, is an overriding mandate which legitimizes--and, in fact, demands--a reasonable degree of risk taking in government procurement. Individual departments would be

required, either by regulation or legislation, to devote at least a small but significant proportion of their procurement budgets to funding Canadian-based research and development--and to buying the successful products that result. An added benefit of this approach is that purchase contracts are far easier to administer than subsidies. It's easy not to renew a contract if results aren't forthcoming. But it's hard for government to terminate a subsidy, once initiated.

This requirement to foster technology development through procurement should also apply to Crown Corporations such as Air Canada, PetroCanada, CN and VIA Rail and Atomic Energy of Canada Ltd. Although these and other federally-owned companies have commissioned some remarkable Canadian innovations, their overall track records are poor relative to the use of their purchasing power to develop Canadian industry. We believe that clear mandates, spelled out in the corporations' enabling legislation, would vastly assist the cause of Canadian technology development.

At present, several key government departments, which buy hundreds of millions of dollars worth of high technology products and services every year, have little or no responsibility or incentive for promoting technology development. The departments of National Defence, Transport, Environment and Energy, Mines and Resources all constitute important markets for high technology products. But under existing institutional arrangements, with a few notable exceptions such as the Canada Center for Remote Sensing, it has been far easier, far safer, for them to buy "off the shelf" products based on proven technologies, often from foreign suppliers, than to take a chance on developing better state-of-the-art Canadian-made alternatives. In some departments, in fact, procurement is specifically limited to "out-of-the-catalogue" items; by definition, this tends to exclude small, innovative Canadian firms which, given the resources and encouragement, might be able to come up with a better product at a lower price.

The lack of creative procurement policies is not solely attributable to bureaucratic caution. It's also caused by a lack of long-term planning--or at least a failure to match tomorrow's requirements with today's purchases. A system which involves present and prospective contractors in the development of specifications, and which funds R&D programs well in advance of the time the resultant products will be

needed, would be of immeasurable benefit. It would allow Canadian firms, operating under long-term government contracts, to produce prototypes well in advance. It would make possible a fairer, more balanced evaluation of these prototypes. It would give the contracting companies additional time in which to develop foreign markets for their innovations. And it would help foster a climate in which success was rewarded, and risk taking was not penalized.

The high technology firms we consulted were unanimous on this point. Many also pointed out the potential benefits that Canada has missed by failing to insist on higher quality industrial benefits/offsets. Offset programs should not be indiscriminately used where international production-sharing agreements are in place, and where their use may be seen by international partners as a violation of such agreements. Offsets are a distant second to the strategy of conducting a long range planning and purchasing strategy to develop Canadian industry. But in those cases where they are appropriate, we believe a matching-dollar approach to industrial offsets can trigger serious distortions. Offsets would be more useful, we believe, if they were based on a qualitative assessment of the industrial benefits to be gained, rather than on a strictly quantitative formula. In the long term, a $500,000 program to improve an automobile engine would be a better deal for Canada than a $1 million contract to manufacture hubcaps.

In spite of the reservations mentioned above, some encouraging reforms of federal procurement policy have already been implemented. For instance, the Department of Supply and Services (DSS) has a policy requiring that its purchases of "mission-oriented" R&D--that is, research aimed at solving specific problems--be contracted out to private firms, rather than conducted by government laboratories. DSS contracted about $250 million in 1983-84 on such private sector research. Under its Unsolicited Proposals (UP) program, with a $15 million annual budget, DSS also provides bridge financing for firms proposing useful R&D projects which cannot be funded from current appropriations. Firms may also benefit from DSS's $10 million Source Development Fund (SDF), which assists them in establishing themselves as potential government suppliers. There is a regrettable tendency, however, for other government departments to try and use SDF and the UP programs as sources of extra funding for projects whose budgets are either inadequate or have been exhausted.

We think that any major expansion of these Department of Supply and Services' programs should be carefully reviewed in the context of their relationship to other industry support programs. The DSS programs are an excellent first step towards an effective procurement policy. But the main impetus for technology procurement should come not from DSS, but from the departments which actually use the products.

UNIVERSITY-INDUSTRY CO-OPERATION

If university laboratories were ever "ivory towers", they are emphatically less so today. Universities now play a central and strategic role in Canada's overall research effort. They tend to take the longer view; although most university research is fundamental, and is concerned with the earlier stages of the innovation chain, it is a crucial link in that chain. Fundamental research carries an additional benefit: it fosters the educational process itself. The social benefits of education--which produces ideas as well as highly-skilled people--plus the long-term benefits of scientific research, make university research extremely cost-effective.

Industry is increasingly recognizing the need to involve the universities in the longer-term aspects of technological development, particularly through research and engineering which is the main conduit between the two sectors. But this dialogue is only just beginning. In the U.S., engineering institutions such as MIT, Stanford and Carnegie-Mellon have become key elements in the maintenance of America's industrial competitiveness. Both industry and government in the U.S. seem more keenly aware of the potential for close co-operation with universities. American universities, in turn, are better equipped to respond to these new industrial demands, in part due to extensive equipment donations by industry. These are due to the more generous tax treatment for such donations in the U.S. We believe it would assist universities if similar provisions were available in Canada.

In Canada, however, there are crippling restraints on our universities' ability to meet the industrial challenges which, increasingly, are being thrust upon them. Among the most serious obstacles are:

* Shrinking revenues: At a time when research demands are increasing, the number of operating dollars per student is decreasing in real terms. This correspondingly reduces the funds available for overhead support of sponsored research.

* The operational inflexibility of many university departments. It is often difficult for them to respond to new demands, because of a plethora of other commitments--to undergraduates, to tenured staff, to existing research facilities and established areas of interest.

* The constraints of federal-provincial financing arrangements. It is beyond our terms of reference to recommend changes in this area, but we feel qualified to comment on the effects. Under the so-called EPF (Established Programs Financing) agreements, Ottawa transfers cash and tax "points" to the provinces to help them pay for health and higher education. Because these funds are not specifically earmarked for the universities, other provincial obligations often receive higher priority. There is no consensus on who, or what, is to blame for this state of affairs; but the fact is that, since the mid-1970's, university revenues per student have declined by about 30 percent in real terms.

It is in this context of dwindling revenues and increasing obligations that the federal government funds university research. Through its three granting agencies, the Natural Sciences and Engineering Research Council (NSERC), the Medical Research Council (MRC) and the Social Sciences and Humanities Research Council (SSHRC), Ottawa distributes about $500 million annually to support research, scientific training and equipment purchases among about 40 Canadian universities.

Because of the expertise of these granting agencies, and because most of their decisions are made with the benefit of extensive peer review, we believe the vast bulk of these dollars are intelligently spent. NSERC is especially effective. Its funding decisions are made not by bureaucrats, but by fellow-members of the scientific community. When it considers the funding of research programs that would have an impact on a particular industry or end user, those interested parties are included in NSERC's decision-making process.

Of all the Canadian agencies, programs and projects we encountered in the course of our research, NSERC was the most widely praised. We believe it must continue to play an important and expanding role in the development of Canada's scientific potential. The principles under which it operates, and which are to some degree responsible for its success, should be applied more widely: industry participation, peer review and a minimum of bureaucratic complexity. In fact, we believe NSERC's success provides a model which could usefully be applied to the federal laboratories and many other federal program areas. The Medical Research Council, we suggest, should also consider the expansion of its support to health industry technology development.

In all, Ottawa's direct sponsorship of university research and scientific training represents less than 8 percent of university operating income. Because most federal funding covers only the incremental research costs, such as supplies, technicians' salaries and equipment, it is estimated that each grant dollar a university receives from Ottawa forces it to spend at least another dollar on facilities, researchers' salaries and other overheads.

There is thus a very real ceiling on the extent to which additional funding under the present arrangements can produce additional research. The ability of the universities to shoulder their portion of a growing research bill is strictly limited. As long as each outside dollar must be matched by another dollar from their own budgets, there are serious constraints on the universities' ability to play a fuller role in technology development.

One remedy for this problem would be for Ottawa to pay the FULL costs of university research that it funds through its agencies. This would involve a fairly radical restructuring of existing arrangements, but the resultant benefits would be correspondingly great:

* It wouldn't necessarily cost any more. If Ottawa were to pay the entire cost of university research projects, rather than incremental costs only, the total sum distributed by the three granting councils would approximately double. But this increase could be accompanied by a reduction in the amounts payable under current transfer arrangements.

* Universities would be relieved of the burden of finding research money of their own to match the amounts available from Ottawa. Removal of this constraint would allow them to become more effective players in the process of technology development.

* Ottawa would get more bang for its research buck, because nearly every R&D dollar the universities received from Ottawa would be allocated according to rigorous criteria of quality, performance and relevance. That's because a much higher proportion of Ottawa's overall aid to universities would be funneled through the granting councils.

* Over the long term, we would expect a full-cost funding system to favour some universities over others.

There's nothing unfair about this. Research funds should not be allocated on the basis of mechanical formulae, but because of demonstrated excellence. Under a full-cost granting system, some universities would tend to excel in specific research areas. Some might develop into true "research universities" on the MIT model. Others, in the natural course of things, would scarcely qualify at all. Many informed observers have decried the lack of specialization in the Canadian university system. We think a full-funding grant system, in the fullness of time, would help bring about a de facto rationalization.

In addition, we believe additional measures are required to stimulate the scientific interchange between industry and academia. Some of these options are already being explored in other jurisdictions. In the U.S., for instance, it is obvious that universities which actively co-operate with industry are generously supported by federal grants and contracts. DARPA finances university research in fundamental science and engineering that has potential commercial importance. In Britain, the government is considering a flat "bonus" of 25 percent of the actual value of research and co-operative work carried out by universities for the private sector. In Ontario, the BILD program for two years provided similar incentive payments to universities which conducted research on behalf of private companies--with dramatic results. NSERC has a new program which provides matching contributions to universities which perform specialized tasks for industry.

It is tempting for government to create a plethora of programs aimed at encouraging this or that aspect of industry-university co-operation. In our view, a flat 25 percent bonus paid to the universities would be far better. It would be vastly cheaper for Ottawa to administer, and much simpler for the intended recipients.

We also favour some corresponding incentive to encourage industry to farm out research to the universities. Under current tax rules, for instance, every dollar a firm spends on R&D earns a 20-30 percent tax credit, which can be applied to current income. A related program allows a 58 percent tax credit to be sold to an outside investor. If companies could earn a 50 percent tax credit for R&D that was performed on their behalf by universities, it would dramatically stimulate the desired dialogue between industry and universities.

As a nation, we cannot afford to waste any scientific or engineering talent. For example, the research support programs of NSERC are presently restricted to individuals who are members of the natural sciences and engineering faculties at a university. We do not see any reason why non-university scientists or engineers should not be eligible to apply to NSERC, if their work meets the excellence criteria and is carried out in facilities that can provide the necessary infrastructure.

A final word on the university-industry interface: at present there are several federal agencies involved in research funding to universities. Their responsibilities frequently overlap. To avoid further costly duplication, their roles should be clarified.

* NSERC's role should be to fund long-term research, build Canada's R&D capacity, train scientific and engineering manpower and act as the overall coordinating agency for federally funded university R&D.

* NRC's role should be to promote the technological capabilities of private sector firms, and to provide them with advice on state-of-the-art technology. To this end, NRC must have access to all sources of research, including that of the universities; its job here is not so much to promote laboratory innovation as to ensure that new technologies make their way into the Canadian marketplace.

* DRIE, inexplicably, is also involved in funding university research. We can see no justification for DRIE's continued involvement in this area.

* The Secretary of State's new program for university centres of specialization appears to be, in our view, a retrogressive step. The program does not appear to employ the traditional peer review system. It unnecessarily duplicates the programs of the granting councils. It is a one shot program. Most university work requires many years of effort for success. Only a tiny handful of work could realistically become self-supporting after a one-time grant.

FEDERAL LABORATORIES

Canada's federal laboratories are justly proud of their long tradition of excellence and innovation. Government-sponsored agricultural research played a key role in the settlement of the Canadian west; defence research during World War II and, later, research into peacetime nuclear applications, helped establish Canada as an international scientific presence. The tradition continues today. In scores of large and small federal laboratories, some 6,000 scientists, assisted by 11,000 support personnel, are engaged in an astonishingly wide variety of pursuits.

We believe, however, that these traditions of excellence are being undermined by a growing atmosphere of irrelevance and an excessively bureaucratic management style. Some laboratories, which once played central roles in national development, now find themselves struggling to find appropriate challenges. Others, whose missions were once so clearly defined that they almost "ran themselves", are now subject to a nit-picking supervisory style which one U.S. authority has aptly dubbed "micro-management". The lack of clearly defined missions, plus an excess of administration, were the criticisms we heard most frequently. In this regard, our findings are strikingly similar to those of the U.S. Federal Laboratory Review Panel, headed by Hewlett-Packard co-founder David Packard, which reported last year to the White House Science Council on the use and performance of U.S. federal laboratories.

It is sometimes argued that the quality of work produced by the federal laboratories would improve if their budgets were increased. We disagree. The problem isn't a lack of money. In fact, we are quite satisfied with the present level of expenditure. The problem, in the case of some labs, has been a lack of constructive criticism from other scientists. We're referring to the tradition of "peer review", by which outside scientists in industry and the universities comment on the quality of their colleagues' work. In our view, this "peer review" process should be strengthened--not only for specific projects, but to monitor the overall relevance and effectiveness of specific laboratory missions. Quality must be pursued in the context of a clearly defined purpose. It is this sense of mission which underlay the early triumphs of so many federal laboratories--and which must be restored if they are to justify their continued operation.

Nearly all federal laboratory research bases its claims to relevance on one of two premises: either it serves the needs of some government agency or it supports the goals of private industry. In the case of acid rain, for instance, government-sponsored research into causes and cures is virtually mandatory. There is a clearly defined need for federally-sponsored agricultural research to support an industry with many individual producers. Nor could private industry in Canada accept the risks or afford the massive expenditures required to create a nuclear power industry. Similarly, many government departments exist, in the words of Stephen Berry of the University of Chicago, to perform "scientific and technical jobs that must be done to keep the nation functioning as we wish it, which no other institution is willing to do". Agencies devoted to monitoring air and water pollution, pesticides and radiation levels, for instance, constitute a large and legitimate market for the output of federal laboratories.

Obviously, some federal laboratories are perceived to be more useful and relevant than others. We did not regard it as part of our role to issue "report cards" on specific laboratories. But we do believe there are clear criteria against which the missions and relevance of all federal laboratories can be judged.

If a federal laboratory exists to support industry, its research and development efforts can be justified if, in addition to being in the national interest:

* the risks or expenditures involved are too high, or the potential payoff too small or too far down the road, to attract private industry;

* the industry is too fragmented to undertake the necessary R&D.

These criteria should be applied rigorously--not only to the review of existing laboratory missions, but to any new research initiatives proposed by the federal government. And it is of crucial importance that the leading players in this process be the very industries that these missions are designed to serve. If a federal laboratory purports to serve an industry, surely that industry is best able to define what that lab should be doing, and to judge how well it's doing it.

This is easier said than done. Most federal laboratories engaged in industrial research are eager to clarify their missions and enhance their usefulness to their clients. But effective consultative mechanisms are lacking. We found many arrangements which were SUPPOSED to foster consultation, but were merely window-dressing.

But industry is not the only part of our society which is affected--or unaffected--by the work of federal laboratories. Universities, scientific and technical training institutions, regional institutions such as Provincial Research Organizations (PROs), trade unions, industry associations, consumer groups--all may have some stake in the federal labs at one time or another. We are not suggesting a mass colloquium of all these diverse interests every time a federal lab wishes to try something new. But just as it is important for a business to know its customers, it is important for a federal laboratory to be aware of the needs of its clientele and of the community in which it operates.

At the moment, they aren't. Industry tends to regard the federal laboratories the way a baseball team might regard a championship cricketer: obviously skilled, but in a totally different game. The research they produce on industry's behalf is seldom used by the industry in question--which is hardly surprising, since industry is seldom asked whether or not they need it. Most industry spokesmen we interviewed believe that government has no place in the industrial laboratories of the nation. They feel there may be a role for federal research in such fields as nuclear power, agriculture or fisheries. But they believe, overwhelmingly, that most of industry-oriented research conducted by government is close to useless--and perhaps even worse than useless, since it tends to drain off talent and resources from more productive employment in the academic and private sectors.

But there are scores of federal laboratories which have nothing to do with industry. Their main client is the federal government itself, whose departments and agencies frequently require research in support of specific government services, such as monitoring water quality, testing consumer products and so on. It is perfectly legitimate, we believe, for the government to support research which improves a department's capacity for:

* testing or monitoring;

* establishing codes, standards or regulations;

* maintaining data bases;

* operating a national facility, such as a wind tunnel or a particle accelerator;

* addressing national or regional problems, such as acid rain;

* carrying out federal obligations in areas of national security and under various international agreements, providing in conjunction with universities a "window" on the international scientific community, and maintaining a national competence in certain key scientific sectors.

Because their main client is the federal government, these laboratories often have even greater difficulty in defining their missions than do labs whose main function is to support industry goals. Inertia, irrelevance, overlapping departmental mandates and jurisdictions are clear and present dangers. These intra-government relationships often lack the results-oriented discipline which characterizes most market transactions. Apart from exhorting federal departments to co-ordinate their missions more rationally, and to demand full value for their research dollar, there is probably no dramatic remedy for the problem.

We're convinced that a more formal structure for monitoring the performance and relevance of federal laboratories is mandatory. In this connection, we warmly endorse the findings of the "Packard Report", which addressed the same problem in the U.S. context:

> "For each federal laboratory, there should be an external oversight function responsible for assuring the continuing excellence of the laboratory. This function could be performed by a committee, which should include strong industry and university representation. This committee would spend enough time at the laboratory to become familiar with (its) strengths and weaknesses. It would focus on productivity and on the excellence, relevance and appropriateness of research. The oversight committee would make recommendations to the agency and inform the laboratory director of

these recommendations. Those recommendations would be taken into account by the agency and laboratory in their budget decisions. In addition, the committee would also give special attention, to reducing micro-management by the sponsoring agency."

We're not necessarily recommending a format precisely like the one Packard recommended. But the underlying principle--that the managers of each laboratory should be held accountable to their clientele --is valid. The challenge is how to make this principle work in the Canadian context. We realize that it would be impractical to appoint separate boards for every laboratory, and that a corporate structure would be inappropriate for many smaller labs, but a liberating force for others.

But when a board is appointed, it should not be a rubber stamp. Its members should be long-term appointees, so that the board is thoroughly familiar with the laboratory's operations. It should be composed of representatives of the laboratory's main "clientele", including private sector members and qualified regional representatives where appropriate. It should not be an "advisory board". Rather, it should have the power to define and review missions, set priorities, and ensure that these goals are reflected in budgetary allocations. In our view, the board's most important job would be mission definition: enhancing the legitimacy of a lab's activities by deciding what the lab should be doing, and on whose behalf. Finally, the manager must be held accountable for the quality, relevance and productivity of the lab. Therefore, the appointments of lab managers should be made for finite terms, and the board should have the authority to extend or abbreviate those terms.

The object of having a board is--literally--to make the federal laboratories more "business-like". Like private businesses, they should be flexible and responsive to their customers' needs. Like businesses, there should be a certain amount of internal competition. In many federal laboratories, there is a tendency to distribute the available funding according to time-honoured formulas. A vigorous lab manager, backed by a vigorous board of directors, might be able to inject an element of competition among scientists and project managers, so that excellence and relevance were rewarded by larger budget allocations. We would therefore recommend that a board of directors representing the

laboratories' main clientele, including the private sector, be established for each laboratory; these boards should be given the authority to define and review missions, set priorities and ensure these goals are reflected in budgetary allocations.

We can even imagine a system whereby individuals or groups of scientists, in cases where sufficient funding for a specific project was unavailable from their own federal laboratory, could receive approval to apply to outside funding sources, such as NSERC--or even the private sector.

Elsewhere in this report, we stress the importance of government procurement as a spur to technology development. In a specialized sense, this observation also applies to the federal laboratories. In fact, some of the government's research organizations are scarcely laboratories at all; they are really highly specialized purchasing agencies, operating under clearly defined missions, which farm out the vast majority of their research tasks to independent contractors.

We believe that this contracting-out approach carries important economic and social dividends, and should be encouraged. It stimulates the development of an independent Canadian research capability. It creates non-government jobs and promotes flexibility. It helps avoid the dangers of bureaucratic ossification.

Since the 1970s, there has been in place a Treasury Board policy requiring that, wherever appropriate, the government's research needs should be met by the private sector, rather than "in-house". The application of this policy has been spotty. It has been most successful in the case of new research programs, such as those of the Canada Centre for Remote Sensing and branches of Transport Canada. It has been less successful in the case of research programs that were already well established. This is hardly surprising; it is in the nature of all organizations to want to keep doing whatever it is they already do. Nevertheless, we applaud the intention behind the policy, and urge that it be more widely applied. It is also important that projects be packaged so that the performer can demonstrate a capability to provide a useful service rather than simply perform a trunkated element of some project.

In our view, R&D should only be done in-house when there is a need for secrecy or neutrality, or when contracting out is not cost-effective in the long run. In-house R&D can also be justified by the need to develop scientific competence in particular areas, or by the need to maintain contacts with the international scientific community. In all other cases, we believe, the government should attempt gradually to shift the bulk of its research requirements to outside contractors. To summarize, greater efforts should be made by laboratories to work with industry by means of contracting out, and that due recognition be given to scientists and administrators supporting these efforts, including the allocation of additional person years where applicable.

The logical extension of the "contracting out" policy is to have a private contractor operate entire laboratories on behalf of their government owner. This is not as fanciful as it may sound; government-owned labs, operated by private contractors, are a permanent and well-regarded feature of the U.S. research establishment. One Canadian example is TRIUMF, the government-owned research facility on the University of B.C. campus, which is operated by a board representing four Canadian universities. Whether GOCO (government-owned, contractor-operated) laboratories are clearly superior to GOGO (government-owned, government-operated) labs is still a matter for lively debate in the U.S. But we believe this model for managing federal laboratories should be used more widely in Canada, on a deliberately experimental basis. Some Scandinavian countries are also experimenting with various hybrid mixtures of private and government ownership of laboratories.

We received significant criticism of the government initiatives in establishing laboratories and programs intended to be of use to industry, but for which industry was never adequately consulted. We believe that no new government-owned research facilities should be established unless it can be demonstrated through an extensive consultative process that a real need exists. The single least popular, recent federal initiative seems to be NRC's proposed manufacturing technology lab in Winnipeg. The way this facility arose constitutes a classic example of almost everything that's wrong with federal technology policy. The lab is supposed to assist industry; but industry was not properly consulted about what, if anything, was needed. In our view, the

facility will be redundant before it's built; the CAD-CAM field is being exhaustively explored in many countries. We need to train and employ people to adapt and exploit new technologies, not create them afresh.

The reforms we have been suggesting may point the way to redeeming this unfortunate endeavor. We recommend that an appropriate industry representative, such as the Canadian Manufacturers Association, be asked to appoint a group of knowledgeable industrialists to define what the manufacturing technology laboratory in Winnipeg should be doing in the CAD-CAM area.

Many complaints about micro-management would disappear if, as we recommend, federal laboratories were made more responsive to market forces. Among the reforms which would assist this goal are:

* Rolling multi-year budgeting: which would lend flexibility and continuity;

* Discretionary resources: There should be a portion of every laboratory's budget and resources that is not earmarked for any specific project. Control of these discretionary resources would make it easier to reward entrepreneurial initiative, and to stimulate interchanges of scientists between university, industry and other government laboratories.

* Personnel incentives: Much more could be done in the federal laboratories to reward extraordinary initiative, and to undermine the "publish-or-perish" syndrome which, in too many cases, is the sole criterion for advancement. More incentives should be established to encourage government scientists to bring their innovative ideas to the marketplace, including particularly opportunities for leave. People are the most important instruments for technology transfer.

* Less paperwork: Federal government scientists complain that they spend too much time on form filling and other burdens of micro-management, to the detriment of their actual research tasks. The remedy is implicit in the reforms we've already recommended.

* More flexibility: We can even imagine a system whereby individuals or groups of scientists, in cases where sufficient funding for a specific project was unavailable from their own federal laboratory, could receive approval to apply to outside funding sources. Mechanisms should be established whereby laboratories and their researchers compete for financial support.

Canada's federal laboratories are a national resource. But their continued effectiveness depends, in the final analysis, on the extent to which they respond to market demand. It was in response to genuine and clearly-defined needs that Canada's federal laboratories established their world-wide reputation for excellence. We believe that closer relationships with end users of the research is the best prescription for their continued vitality. There may be many administrative approaches to achieving this, and it is not our role to choose one model over another. But a serious attempt must be made to make the federal laboratories more "business-like", more demand-driven. And in this case, we believe the direction is as important as the destination.

We therefore recommend that a review of all federal laboratories be carried out, with each laboratory being required to demonstrate to a designated central agency its relevance and usefulness.

RECOMMENDATIONS

We believe this report speaks for itself. Its thrust is that government policies and programs aimed at technology development are not working well, and in some cases are not working at all.

We also believe that technology is at the heart of Canada's well being and any government in Canada must include as one of its highest priorities the need to manage technological change for the benefit of Canadians. The government's role is to set a climate that encourages the private sector to adapt and use the most up-to-date world technologies and create new technologies when they will respond to market opportunities where Canada has a comparative advantage.

The recommendations presented below could form the basis for change--but only if the government acts vigorously to build upon them.

Our first and perhaps most important recommendation, accordingly, is that the government, upon receipt of this report, immediately initiate a process aimed at its implementation. That process should begin with the report's approval in principle by Cabinet. The Cabinet should then direct a Minister, perhaps the Minister responsible for science and technology, to work out the details of implementation within a given period of time --a year, say, or 18 months. This phase of the implementation process should involve consultation with the main players: the departments and agencies involved, the universities, the private sector and the government laboratories.

We believe the time is ripe for meaningful change. The approach to implementation we propose--which has been successful in other countries--might avert the fate that has befallen so many of this report's predecessors --to be studied and stalled to death.

The recommendations contained throughout the report are summarized as follows:

1. Implementation

Technology development is of overriding importance to Canada's continued prosperity--indeed, to our survival as an industrial power. As such, it deserves top-priority political attention. The federal government's various efforts to promote technology development--now an overlapping patchwork of programs, policies and institutions--must be reshaped into a total package. And that technology development package must be administered by a single ministry or department, equipped with the necessary authority to implement policy changes, and to oversee and coordinate the research work of government laboratories with that of the private sector.

- our first and perhaps most important recommendation, accordingly, is that government, upon receipt of this report, immediately initiate a process aimed at its implementation. (p. 35)

- the federal government's involvement in technology development must be redefined to maximize the market's "pull" on the innovation process. (p. 2)

- we believe that the responsibility for actively supporting technology development should be made an explicit part of all appropriate departments' mandates and that the Chief Science Advisor should report regularly to the Prime Minister on technology development issues. (p. 5)

2. Human and Social Benefits

The social and human consequences of technological change are substantial, but they are imperfectly understood. The impact of technological innovation on employment and working conditions has not received the attention it deserves from researchers or policy makers. This most important subject should be studied by a federal task force created for the purpose, or by an existing organization, such as the Labour Market Productivity Centre. The federal government must find ways to minimize the human costs of technological change, and to ensure that innovation enhances the quality of life of all Canadians. Measures such as making social science research eligible for tax incentives should be considered.

- to realize this potential (social impact to improve the quality of our lives) will require that we marshall our wit and skill, bringing together labour and management in productive enterprise. (p. 1)

- a task force or organization devoted to that subject alone (the social impact of new technologies), we believe, would be a more appropriate response to the urgency and magnitude of the issues involved. (p. 1)

3. Industry Support Programs

The process of technology development works best in response to the "pull" of clearly defined market needs. It is futile for government to attempt to manage this process, or to attempt to usurp the market's role by trying to pick winners. Government's most effective role is in "climate setting"--that is, in establishing an environment in which innovation can flourish. This role, we believe, should involve a gradual shift from subsidy programs to more generalized forms of industry incentives.

- we recommend a thorough review of all these programs be carried out by a responsible ministry or department, such as MOSST, with a view to gradually phasing out those which have failed to win the endorsement of their intended clientele. (p. 10)

- we believe that responsibility for administering the technology development portions of the IRDP should be transferred from DRIE to the National Research Council. (p. 10).

- the administration of technology development programs should be simplified to reflect a much greater willingness on the part of government to share the risks of technology development. (p. 9)

- one possible alternative to the funding of small industrial R&D projects, of say less than $35,000, would be for the federal government to delegate this responsibility to provincial organizations. (p. 10).

- (there is a) need to extend the R&D definition that is now used by Revenue Canada, to make it more compatible with the definition used in the United States. (p. 11)

4. Government Procurement

Procurement is one of the most effective means by which government can promote technology development. Ottawa's vast purchasing power is a tool--so far insufficiently used--which could provide the market "pull" for the development of a host of new products, technologies and even industries. Every government department with substantial purchasing commitments must be required to include technology development among its major priorities.

Procurement-based innovation policies should include (through international production sharing agreements and multi-country joint venture projects) access to larger markets than Canada can itself provide. Industrial benefits or offsets associated with major Canadian government procurements should not be used where such agreements might be thereby jeopardized. Where appropriate to use offsets, evaluated benefits should reflect quality rather than quantity.

- we do advocate a policy that would effectively utilize the federal governments' immense purchasing power to promote private sector innovation. (p. 13)

- what is lacking, we believe, is an overriding mandate which legitimizes--and, in fact, demands--a reasonable degree of risk taking in government procurement. (p. 14)

- the lack of creative procurement policies is not solely attributable to bureaucratic caution. It is also caused by lack of long-term planning. (p. 15)

- we think that any major expansion of Department of Supply and Services' programs should be carefully reviewed in the context of their relationship to other industry support programs. (p. 17)

5. University-Industry, and Government Interface

University research is doubly important, in that it simultaneously produces not only ideas, but trained people. We strongly endorse the knowledgeable, unbureaucratic methods by which NSERC funds university research, supports engineering, science and mathematics, funds strategic work in emerging technologies and works to promote greater industry participation in technology development.

- one remedy for this problem (matching funding from universities) would be for Ottawa to pay the FULL costs of university research that it funds through its agencies. (p. 21)

- in our view, a flat 25 percent bonus paid to universities (participating in industrial R&D contracts) would be far better (at encouraging industry-university co-operation). (p. 22)

- if companies could earn a 50 percent tax credit for R&D that was performed on their behalf by universities, it would dramatically stimulate the desired dialogue between industry and universities. (p. 22)

- NSERC's role should be to fund long-term research, build Canada's R&D capability, train scientific and engineering manpower and act as an overall coordinating agency for federally funded university R&D. (p. 23)

6. Federal Laboratories

Federal laboratories have a legitimate role to play in meeting the clearly defined needs of government and, in a few specialized cases, supporting the needs of industry. But government laboratories cannot be justified if their missions could be fulfilled equally well by the private sector.

- we believe, however, that these traditions of excellence are being undermined by a growing atmosphere of irrelevance and an excessively bureaucratic management style. (p. 25)

- in our view, this "peer review" process should be strengthened--not only for specific projects, but to monitor the overall relevance and effectiveness of specific laboratory missions. Quality must be pursued in the context of clearly defined purpose. (p. 25)

- we would therefore recommend that a board of directors representing the laboratories' main clientele, including the private sector, be established for each laboratory; these boards should be given the authority to define and review missions, set priorities and ensure these goals are reflected in budgetary allocations. (pp. 29-30)

- to summarize, greater efforts should be made by laboratories to work with industry by means of contracting out and that due recognition be given to scientists and administrators supporting these efforts. (p. 31)

- we believe this model for managing federal laboratories (government-owned, contractor-operated) should be used more widely in Canada, on a deliberately experimental basis. (p. 31)

- we believe that no new government-owned facilities should be established unless it can be demonstrated through an extensive consultative process that a real need exists. (p. 31)

- more incentives should be established to encourage government scientists to bring their innovative ideas to the marketplace, including particularly opportunities for leave. (p. 32)

- mechanisms should be established whereby laboratories and their researchers compete for financial support. (p. 32)

- we therefore recommend that a review of all federal laboratories be carried out with each laboratory being required to demonstrate to a designated central agency, such as MOSST,its relevance and usefulness. (p. 33)

APPENDIX

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